

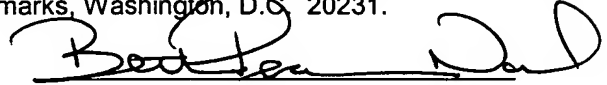


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APPLICATION FOR UNITED STATES LETTERS PATENT

FOR

METHOD OF UTILIZING FLOWABLE DEVICES IN WELLBORES

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CROSS-REFERENCE TO RELATED APPLICATIONS

This application takes priority from United States Patent Application Serial Nos. 60/136,656 filed August 5, 1999, and 60/147,127 filed May 28, 1999, each assigned to the assignee of this application.

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BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to oilfield wellbores and more particularly to wellbore systems and methods for the use of flowable devices in such wellbores.

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2. Background of the Art

Hydrocarbons, such as oil and gas, are trapped in subsurface formations. Hydrocarbon-bearing formations are usually referred to as the producing zones or oil and gas reservoirs or "reservoirs." To obtain hydrocarbons from such formations, wellbores or boreholes are drilled from a surface location or "well site" on land or offshore into one or more such reservoirs. A wellbore is usually formed by drilling a borehole of a desired diameter or size by a drill bit conveyed from a rig at the well site. The drill string includes a hollow tubing attached to a drilling assembly at its bottom end. The drilling assembly (also referred to herein as the "bottomhole assembly" or "BHA") includes the drill bit for drilling the wellbore and a number of sensors for determining a variety of subsurface or downhole parameters. The tubing usually is a continuous pipe made by joining relatively small sections (each

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section being 30-40 feet long) of rigid metallic pipe (commonly referred to as the "drill pipe") or a relatively flexible but continuous tubing on a reel (commonly referred to as the "coiled-tubing"). When coiled tubing is used, the drill bit is rotated by a drilling motor in the drilling assembly. Mud motors are most commonly utilized as drilling motors. When a drill pipe is used as the tubing, the drill bit is rotated by rotating the drill pipe at the surface and/or by the mud motor. During drilling of a wellbore, drilling fluid (commonly referred to as the "mud") is supplied under pressure from a source thereof at the surface through the drilling tubing. The mud passes through the drilling assembly, rotates the drilling motor, if used, and discharges at the drill bit bottom. The mud discharged at the drill bit bottom returns to the surface via the spacing between the drill string and the wellbore (also referred herein as the "annulus") carrying the rock pieces (referred to in the art as the "cuttings") therewith.

Most of the currently utilized drilling assemblies include a variety of devices and sensors to monitor and control the drilling process and to obtain valuable information about the rock, wellbore conditions, and the matrix surrounding the drilling assembly. The devices and sensors used in a particular drilling assembly depend upon the specific requirements of the well being drilled. Such devices include mud motors, adjustable stabilizers to provide lateral stability to the drilling assembly, adjustable bends, adjustable force application devices to maintain and to alter the drilling direction, and thrusters to apply desired amount of force on the

drill bit. The drilling assembly may include sensors for determining (a) drilling parameters, such as the fluid flow rate, rotational speed (r.p.m.) of the drill bit and/or mud motor, the weight on bit ("WOB"), and torque of the bit; (b) borehole parameters, such as temperature, pressure, hole size and shape, and chemical and physical properties of the circulating fluid, inclination, azimuth, etc., (c) drilling assembly parameters, such as differential pressure across the mud motor or BHA, vibration, bending, stick-slip, whirl; and (d) formation parameters, such as formation resistivity, dielectric constant, porosity, density, permeability, acoustic velocity, natural gamma ray, formation pressure, fluid mobility, fluid composition, and composition of the rock matrix.

During drilling, there is ongoing need to adjust the various devices in the drill string. Frequently, signals and data are transmitted from surface control units to the drilling assembly. Data and the sensor results from the drilling assembly are communicated to the surface. Commonly utilized telemetry systems, such as mud pulse telemetry and acoustic telemetry systems, are relatively low data rate transfer systems. Consequently, large amounts of downhole measured and computed information about the various above-noted parameters is stored in memory in the drilling assembly for later use. Also, relatively few instructions and data can be transmitted from the surface to the drilling assembly during the drilling operations.

After the well has been drilled, the well may be completed, i.e., made ready for production. The completion of the wellbore requires a variety of operations, such as setting a casing, cementing, setting packers, operating flow control devices, and perforating. There is need to send signals and data from the surface during such completion operations and to receive information about certain downhole parameters. This information may be required to monitor status and/or for the operation of devices in the wellbore ("downhole devices"), to actuate devices to perform a task or operation or to gather data about the subsurface wellbore completion system, information about produced or injected fluids or information about surrounding formation. After the well has started to produce, there is a continuous need to take measurements of various downhole parameters and to transmit downhole generated signals and data to the surface and to receive downhole information transmitted from the surface.

The present invention provides systems and methods wherein discrete flowable devices are utilized to communicate surface-generated information (signals and data) to downhole devices, measure and record downhole parameters of interest, and retrieve from downhole devices, and to make measurements relating to one or more parameters of interest relating to the wellbore systems.

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SUMMARY OF THE INVENTION

This invention provides a method of utilizing flowable devices to communicate between surface and downhole instruments and to measure downhole parameters of interest.

In one method, one or more flowable devices are introduced into fluid flowing in the wellbore. The flowable device is a data carrier, which may be a memory device, a measurement device that can make one or more measurements of a parameter of interest, such as temperature, pressure and flow rate, and a device with a chemical or biological base that provides some useful information about a downhole parameter or a device that can transfer power to another device.

In one aspect of the invention, memory-type flowable devices are sent downhole wherein a device in the wellbore reads stored information from the flowable devices and/or writes information on the flowable device. If the flowable device is a measurement device, it takes the measurement, such as temperature, pressure, flow rate, etc., at one or more locations in the wellbore. The flowable devices flow back to the surface with the fluid, where they are retrieved. The data in the flowable devices and/or the measurement information obtained by the flowable devices is retrieved for use and analysis.

During drilling of a wellbore, the flowable devices may be introduced into the drilling fluid pumped into the drill string. A data exchange device in the drill string reads information from the flowable devices and/or writes information on the

flowable devices. An inductive coupling device may be utilized for reading information from or writing information on the flowable devices. A downhole controller controls the information flow between the flowable device and other downhole devices and sensors. The flowable devices return to the surface with the circulating drilling fluid and are retrieved. Each flowable device may be assigned an address for identification. Redundant devices may be utilized.

In a production well, the flowable devices may be pumped downhole via a tubing that runs from a surface location to a desired depth in the wellbore and then returns to the surface. A U-shaped tubing may be utilized for this purpose. The flowable devices may also be carried downhole via a single tubing or stored in a container or magazine located or placed at a suitable location downhole, from which location the flowable devices are released into the flow of the produced fluid, which carries the flowable devices to the surface. The release or disposal from the magazine may be done periodically, upon command, or upon the occurrence of one or more events. The magazine may be recharged by intervention into the wellbore. The tubing that carries the flowable devices may be specifically made to convey the flowable devices or it may be a hydraulic line with additional functionality. The flowable devices may retrieve information from downhole devices and/or make measurements along the wellbore. A plurality of flowable devices may be present in a wellbore at any given time, some of which may be designed to communicate with other flowable device or other downhole device, thereby providing a

communication network in the wellbore. The flowable devices may be intentionally implanted in the wellbore wall to form a communication link or network in the wellbore. A device in the wellbore reads the information carried by the flowable devices and provides such information to a downhole controller for use. The information sent downhole may contain commands for the downhole controller to perform a particular operation, such as operating a device. The downhole controller may also send information back to the surface by writing information on the flowable devices. This may be information from a downhole system or confirmation of the receipt of the information from surface.

Examples of the more important features of the invention have been summarized rather broadly in order that the detailed description thereof that follows may be better understood, and in order that the contributions to the art maybe appreciated. There are, of course, additional features of the invention that will be described hereinafter and which will form the subject of the claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

For a detailed understanding of the present invention, reference should be made to the following detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings, in which like elements have been given like numerals, wherein:

Figure 1 is a schematic illustration of a drill string in a wellbore during drilling of a wellbore, wherein flowable devices are pumped downhole with the drilling fluid.

Figure 2 is a schematic illustration of a wellbore during drilling wherein
5 flowable devices are implanted in the borehole wall to form a communications line in the open hole section and wherein a cable is used for communication in the cased hole section.

Figure 3 is a schematic illustration of a wellbore wherein flowable devices
10 are pumped downhole and retrieved to the surface via a U-shaped hydraulic or fluid line disposed in the wellbore.

Figure 4 is a schematic illustration of a production well wherein flowable
15 devices are released in the flow of the produced fluid at a suitable location.

Figure 5 is a schematic illustration of a multi-lateral production wellbore wherein flowable devices are pumped down through a hydraulic line and released into the fluid flow of the first lateral and where information is communicated from the

first lateral to the second lateral through the earth formation and wherein flowable devices may also be released into the fluid flow of the second lateral to carry such devices to the surface.

5 **Figure 6** is a block functional diagram of a flowable device according to one embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

10 The present invention utilizes "flowable devices" in wellbores to perform one or more functions downhole. For the purpose of this disclosure, a flowable device means a discrete device which is adapted to be moved at least in part, by a fluid flowing in the wellbore. The flowable device according to this invention is preferably of relatively small size (generally in the few millimeters to a centimeter range in outer dimensions) that can perform a useful function in the wellbore. Such a device
15 may make measurements downhole, sense a downhole parameter, exchange data with a downhole device, store information therein, and/or store power. The flowable device may communicate data and signals with other flowable devices and/or devices placed in the wellbore ("downhole devices"). The flowable device may be programmed or coded with desired information. An important feature of the
20 flowable devices of the present invention is that they are sufficiently small in size so that they can circulate with the drilling fluid without impairing the drilling operations. Such devices preferably can flow with a variety of fluids in the wellbore. In another

aspect of the invention, the devices may be installed in the wellbore wall either permanently or temporarily to form a network of devices for providing selected measurement of one or more downhole parameters. The various aspects of the present invention are described below in reference to **Figures 1-6** utilizing
5 exemplary wellbores.

In a preferred embodiment, the flowable device may include a sensor for providing measurements relating to one or more parameters of interest, a memory for storing data and/or instructions, an antenna for transmitting and/or receiving
10 signals from other devices and/or flowable devices in the wellbore and a control circuit or controller for processing, at least in part, sensor measurements and for controlling the transmission of data from the device, and for processing data received from the device. The device may include a battery for supplying power to its various components. The device may also include a power generation device
15 due to the turbulence in the wellbore fluid flow. The generated power may be utilized to charge the battery in the device.

Figure 1 is an illustration of the use of flowable devices during drilling of a wellbore, which shows a wellbore **10** being drilled by a drill string **20** from a surface
20 location **11**. A casing **12** is placed at an upper section of the wellbore **10** to prevent collapsing of the wellbore **10** near the surface **11**. The drilling string **20** includes a tubing **22**, which may be a drill pipe made from joining smaller sections of rigid pipe

or a coiled tubing, and a drilling assembly **30** (also referred to as a bottom hole assembly or "BHA") attached to the bottom end **24** of the tubing **22**.

5 The drilling assembly **30** carries a drill bit **26**, which is rotated to disintegrate the rock formation. Any suitable drilling assembly may be utilized for the purpose of this invention. Commonly used drilling assemblies include a variety of devices and sensors. The drilling assembly **30** is shown to include a mud motor section **32** that includes a power section **33** and a bearing assembly section **34**. To drill the wellbore **10**, drilling fluid **60** from a source **62** is supplied under pressure to the
10 tubing **22**. The drilling fluid **60** causes the mud motor **32** to rotate, which rotates the drill bit **26**. The bearing assembly section **34** includes bearings to provide lateral and axial stability to a drill shaft (not shown) that couples the power section **33** of the mud motor **32** to the drill bit **26**. The drilling assembly **30** contains a plurality of direction and position sensor **42** for determining the position (x, y and z coordinates)
15 with respect to a known point and inclination of the drilling assembly **30** during drilling of the wellbore **10**. The sensors **42** may include, accelerometers, inclinometers, magnetometers, and navigational devices. The drilling assembly further includes a variety of sensors denoted herein by numeral **43** for providing information about the borehole parameters, drilling parameters and drilling
20 assembly condition parameters, such as pressure, temperature, fluid flow rate, differential pressure across the mud motor, equivalent circulatory density of the

drilling fluid, drill bit and/or mud motor rotational speed, vibration, weight on bit, etc. Formation evaluation sensors **40** (also referred to as the "FE" sensors) are included in the drilling assembly **30** to determine properties of the formations **77** surrounding the wellbore **10**. The FE sensors typically include resistivity, acoustic, nuclear and
5 nuclear magnetic resonance sensors which alone provided measurements that are used alone or in combination of measurements from other sensors to calculate, among other things, formation resistivity, water saturation, dielectric constant, porosity, permeability, pressure, density, and other properties or characteristics of the formation **77**. A two-way telemetry unit **44** communicates data/signals between
10 the drilling assembly **30** and a surface control unit or processor **70**, which usually includes a computer and associated equipment.

During drilling, according to one aspect of the present invention, flowable devices **63** are introduced at one or more suitable locations into the flow of the
15 drilling fluid **60**. The flowable devices **63** travel with the fluid **60** down to the BHA **30** (forward flow), wherein they are channeled into a passage **69**. A data exchange device **72**, usually a read/write device disposed adjacent to or in the passage **69**, which can read information stored in the devices **63** (at the surface or obtained during flow) and can write on the devices **63** any information that needs to be sent
20 back to the surface **11**. An inductive coupling unit or another suitable device may be used as a read/write device **72**. Each flowable device **63** may be programmed

at the surface with a unique address and specific or predetermined information. Such information may include instructions for the controller **73** or other electronic circuits to perform a selected function, such as activate ribs **74** of a force application unit to change drilling direction or the information may include signals for the controller **73** to transmit values of certain downhole measured parameters or take another action. The controller **73** may include a microprocessor-based circuit that causes the read/write unit **72** to exchange appropriate information with the flowable devices **63**. The controller **73** process downhole the information received from the flowable devices **63** and also provides information to the devices **63** that is to be carried to the surface. The read/write device **72** may write data that has been gathered downhole on the flowable devices **63** leaving the passage **69**. The devices **63** may also be measurement or sensing devices, in that, they may provide measurements of certain parameters of interest such as pressure, temperature, flow rate, viscosity, composition of the fluid, presence of a particular chemical, water saturation, composition, corrosion, vibration, etc. The devices **63** return to the surface **11** with the fluid circulating through the annulus **13** between the wellbore **10** and drill string **22**.

The flowable devices returning to the surface designated herein for convenience by numeral **63a** are received at the surface by a recovery unit **64**. The returning devices **63a** may be recovered by filtering magnetic force or other

techniques. The information contained in the returning devices **63a** is retrieved, interpreted and used as appropriate. Thus, in the drilling mode, the flowable devices **63** flow downhole where they perform an intended function, which may be taking measurements of a parameter of interest or providing information to a downhole controller **73** or retrieving information from a downhole device. The devices **63a** return to the surface (the return destination) via the annulus **13**.

During drilling, some of the devices may be lost in the flow process or get attached or stuck to the wall of the wellbore **10**. Redundant devices may be supplied to account for such loss. Once the controller **73** has communicated with a device having a particular address, it may be programmed to ignore the redundant device. Alternatively, the controller **73** may cause a signal to be sent to the surface confirming receipt of each address. If a particular address is not received by the downhole device **72**, a duplicate device may be sent. The devices **63a** that get attached to the wellbore wall **10a** (see **Figure 2**), may act as sensors or communication locations in the wellbore **10**. A stuck device may communicate with another flowable device stuck along the wall **10a** or with devices passing adjacent the stuck device, thereby forming a communications network. The returning devices **63a** can retrieve information from the devices stuck in the well **10**. Thus, the flowable devices in one aspect, may form a virtual network of devices which can pass data/information to the surface. Alternatively, some of the devices **63** may be

adapted or designed to lodge against or deposited on the wellbore wall **10a**, thereby providing permanent sensors and/or communication devices in the wellbore **10**. In one embodiment, the flowable devices may be designed to be deposited on the borehole wall during the drilling process. As one flowable device can communicate with another neighboring flowable device, a plurality of flowable devices deposited on the wellbore wall may form a communications network. As drilling of new formation continues new flowable devices are constantly deposited on the borehole wall to maintain the network. When drilling of the section is completed, the flowable devices may be retrieved from the borehole wall for use in another application. The devices **63** may include a movable element that can generate power due to turbulence in the wellbore fluid, which power can be used to change a resident battery in the flowable devices. Further, the devices **63** may include a propulsion mechanism (as more fully explained in reference to **Figure 6**) that aids these devices in flowing with or in the fluid **60**. The devices **63** usually are autonomous devices and may include a dynamic ballast that can aid such devices to flow in the fluid **60**.

Flowable devices may also be periodically planted in the wellbore wall in a controlled operation to form a communication line along the wellbore, as opposed to randomly depositing flowable devices using the hydraulic pressure of the drilling fluid. An apparatus may be constructed as part of the downhole assembly to mechanically apply a force to press or screw the flowable device into the wellbore

5 wall. In this operation, the force required to implant the device may be measured, either by sensors within the flowable device itself or sensors within the implanting apparatus. This measured parameter may be communicated to the surface and used to investigate and monitor rock mechanical properties. The flowable devices
10 may be pumped downhole to the planting apparatus, or kept in a magazine downhole to be used by the planting apparatus. In this case the flowable devices may be permanently installed. **Figure 2** which is a schematic illustration of a wellbore, wherein devices made in accordance with the present invention are implanted in the borehole wall during drilling of the wellbore **10** to form a communication network. **Figure 2** shows a well **10** being drilled by drill bit **26** at the bottom of a drilling assembly **80** carried by a drilling tubing **81**. Drilling fluid **83** supplied under pressure through the tubing **81** discharges at the bottom of the drill bit **26**. Flowable devices **63** are introduced or pumped into the fluid **83** and captured or retrieved by a device **84** in the drilling assembly **80**. The drilling assembly **80**
15 includes an implanting device **85** that implants the retrieved flowable devices **63** via a head **86** into the borehole wall **10a**. The devices which are implanted during the drilling of the wellbore **10** are denoted by numeral **63b**. The devices **63** may be pumped downhole through a dedicated tubing **71** placed in the drilling tubing **81**. If coiled tubing is used as the tubing **81**, the tubing **71** for carrying the flowable
20 devices **63** to the implanter **85** may be built inside or outside the coiled tubing.

Alternatively, the devices to be implanted may be stored in a chamber or magazine **83**, which deliver them to the implanter **85**. The implanted flowable devices **63b** in the well **10** can exchange data with each other and/or other flowable devices returning to the surface via the annulus **13** and/or with other devices in the drill string as described above in reference to **Figure 1**. A communication device **88** may be disposed in the well at any suitable location, such as below the upper casing **12** to communicate with the implanted devices **63b**. The communication device **88** may communicate with one or more nearby flowable devices **63b** such as a device denoted by numeral **63b'**, which device then communicates with next device and so forth down the line to the remaining implanted devices **63b**. Similarly, the implanted devices **63b** communicate uphole up to the devices **63b'** which communicates with the device **88**, thus establishing a two-way communication link or line along the wellbore **10**. The device **88** can read data from and write data on the devices **63b**. It is operatively coupled to a receiver/transmitter unit **87** and a processor **89** at the surface by a conductor or link **91**. The link **91** may be an electrical conduct or a fiber optic link. The processor **89** processes the data received by the receiver/transmitter unit **87** from the devices **63b** and also sends data to the devices **63b** via the receiver/transmitter **87**. The implanted devices **63b** may be used to take measurements for one or more selected downhole parameters during and after the drilling of the wellbore **10**.

Figure 3 illustrates an alternative method of transporting the devices **63** to a downhole location. **Figure 3** shows a wellbore **101** formed to a depth **102**. For simplicity and ease of understanding, normal equipment and sensors placed in a wellbore are not shown. A fluid conduit **110** is disposed in the wellbore. The
5 conduit **110** runs from a fluid supply unit **112**, forms a U-return **111** and returns to the surface **11**. Flowable devices **63** are pumped into the conduit **110** by the supply unit **112** with a suitable fluid. A downhole device **72a** retrieves information from the flowable devices **63** passing through a channel **70a** and/or writes information on such devices. A controller **73a** receives the information from the flowable devices
10 **63** and utilizes it for the intended purpose. Controller **73a** also controls the operation of the device **72a** and thus can cause it to transfer the required information onto the flowable devices **63**. The flowable devices **63** then return to the surface via the return segment **110a** of the tubing **110**. A retrieval unit **120** at the surface recovers the returning flowable devices **63a**, which may be analyzed by
15 a controller **122** or by another method. The devices **63** may perform sensory and other functions described above in references to **Figure 1**.

Figure 4 is a schematic illustration of a production well **200** wherein flowable devices **209** are released into the produced fluid or formation fluid **204**, which
20 carries these devices to the surface. **Figure 4** shows a well **201** that has an upper casing **203** and a well casing **202** installed therein. Formation fluid **204** flows into

the well **201** through perforations **207**. The fluid **204** enters the wellbore and flows to the surface via a production tubing **210**. For simplicity and ease of understanding, **Figure 4** does not show the various production devices, such as flow control screens, valves and submersible pumps, etc. A plurality of flowable devices **209** are stored or disposed in a suitable container at a selected location **211** in the wellbore **201**. The devices **209** are selectively released into the flow of the produced fluid **204**, which fluid carries these devices, the released devices are designated by numeral **209a** to the surface. The devices **209a** are retrieved by a retrieval unit **220** and analyzed. As noted above in reference to **Figures 1** and **3**, the flowable devices **209a** may be sensor devices or information containing devices or both. Periodic release of sensory devices can provide information about the downhole conditions. Thus, in this aspect of the invention, the flowable devices are released in the well **201** to transfer downhole information during the production phase of the well **201**.

Communication in open-hole sections may be achieved using flowable devices in the drilling mud deposited on the borehole wall, or by using implanted flowable devices as described above. In cased hole sections often found above open-hole sections, communications may be achieved in several ways; through flowable devices deposited in the mud filter cake or implanted in the borehole wall during the drilling process, or through flowable devices mixed in the cement which

fills the annulus between the borehole wall/mud filter cake and the casing, or through a communication channel installed as part of the casing. The latter may include a receiver at the bottom of the casing to pick up information from the devices, and a transmitter to send this information to the surface and vice versa.

5 The communication device associated with the casing could be an electrical or fibre-optic or other type of cable, an acoustic signal or an electromagnetic signal carried within the casing or within the earth, or other methods of communication. In conclusion, a communication system based on the use of flowable devices may be used in combination with other communication methods to cover different sections

10 of the wellbore, or to communicate over distances not covered by a wellbore.

Another example of using flowable devices in combination with other communication systems is a multilateral well. One or more laterals of the well may have a two-way communication system with flowable devices, while one or more

15 laterals of the same well may not have a full two-way communication system with the flowable devices. In one embodiment of the invention, the first lateral is equipped with a single tube or a U-tube that allows flowable devices containing information from surface to travel to the bottom of the first lateral. The second lateral is not equipped with a tubing, but has flowable devices stored in a downhole

20 magazine. A message to the second lateral is pumped into the first lateral. From the receiver station in the first lateral, information such as a command to release a flowable device in the second lateral, is transmitted from the first lateral to the

second lateral through acoustic or electromagnetic signals through the earth. Upon receipt of this information in the second lateral, the required task, such as writing to and releasing a flowable device or initiating some action downhole is performed. Provided the distance and formation characteristics allow transmission of signal
5 through the earth formation, the same concept can be used to communicate between individual wellbores.

Figure 5 is an exemplary schematic illustration of an multilateral production well **300**, wherein flowable devices are pumped into one branch or lateral and then
10 utilized for communication between the laterals. **Figure 5** shows a main well section **301** having two branch wells or laterals **301a** and **301b**. In the exemplary lateral wellbore configuration of **Figure 5**, both wells **301a** and **301b** are shown to be production wells. Well **301a** and **301b** produce fluids (hydrocarbons) which are shown by arrow **302a** and **302b**, respectively. Flowable devices **63** are pumped into
15 the first lateral **301a** via a tubing **310** from a supply unit **321** at the surface **11**. The devices **63** are discharged at a known depth **303a** where a receiver unit **370a** retrieves data from the devices **63**. The devices return to the surface with the produced fluid **302a**. The returning devices from wellbore **301** are denoted by **63d**. A transmitter unit **380** transmits signals **371** in response to information retrieved
20 from the flowable devices **63**. A second receiver **370b** in the second lateral **301b** receives signals **371**. A controller unit or processor **382** utilizes the received signals

to perform an intended function or operation, which may include operating a device downhole, such as a valve, a sliding sleeve, or a pump, etc. Flowable devices **63c** may be disposed in magazine **383** in the second lateral **301b** and released into the fluid flow **302b** by the controller **382**. The devices **63d** and **63c** flowing uphole are
5 retrieved at the surface by a receiver unit **320** and the data carried by the flowable devices **63c** and **63d** is processed by the processor **322**. It should be noted that **Figure 5** is only one example of utilizing the flowable devices in multiple wellbores. The wells selected for intercommunication may be separate wells in a field. The signals **371** may be received by instruments in one or more wells and/or at the
10 surface for use in performing an intended task.

Figure 6 shows a block functional diagram of a flowable device **450** according to one embodiment of the present invention. The device **450** is preferably encapsulated in a material **452** that is suitable for downhole environment such as
15 ceramic, and includes one or more sensor elements **454**, a control circuit or controller **456** and a memory unit **458**. A resident power supply **460** supplies power to the sensor **454**, controller **456**, memory **458** and any other electrical component of the device **450**. The controller **456** may include a processor that interacts with one or more programs in the device to process the data gathered by the device
20 and/or the measurements made by the device to compute, at least partly, one or more parameters of interest, including results or answers. For example, the device

450 may calculate a parameter, change its future function and/or transmit a signal in response to the calculated parameter to cause an action by another flowable device or a device in the wellbore. For example, the device may determine a detrimental condition downhole, such as presence of water and then send a signal to a fluid flow control device in the wellbore to shut down a production zone or the well. The device may be designed to have sufficient intelligence and processing capability so it can take any number of different actions in the wellbore. A power generation unit that generates electrical power due to the turbulence in the flow may be incorporated in the device **450** to charge a battery (resident power supply) **460**.

An antenna **462** is provided to transmit and/or receive signals, thereby providing one-way or two-way communication (as desired) between the flowable device **450** and another device, which may be a flowable device or a device located downhole or at the surface. The device **450** may be programmed at the surface or downhole to carry data and instructions. The surface information programmed into a flowable device is read by a device in the wellbore while the downhole programmed information may be read at the surface or by reading devices downhole. The device **450** may transmit and receive signals in the wellbore and thus communicate with other devices. Such a flowable device can transfer or exchange information with other devices, establish communication link along the wellbore, provide two-way communication between surface and downhole devices, or between different wellbores in a field or laterals of a wellbore system, and establish a communication network in the wellbore and/or between the surface instrumentation and downhole

devices. Each such device may be coded with an identification number or address, which can be utilized to confirm the receipt or transfer of information by the devices deployed to receive the information from the flowable device **450**. In one method, the flowable device **450** may be sequentially numbered and introduced into the fluid flow to be received at a target location. If the receiving device receives a flowable device, it can cause a signal to be sent to the sending location, thereby confirming the arrival of a particular device. If the receiving device does not confirm the arrival of a particular device, a second device carrying the same information and the address may be sent. This system will provide a closed loop system for transferring information between locations.

In another aspect of the invention, the flowable device may contain a chemical that alters a state in response to a downhole parameter, which provides a measure of a downhole parameter. Other devices, such as devices that contain biological mass or mechanical devices that are designed to carry information or sense a parameters may also be utilized. In yet another aspect, the flowable device may be a device carrying power, which may be received by the receiving device. Thus, specially designed flowable devices may be utilized to transfer power from one location to another, such as from the surface to a downhole device.

The flowable device **450** may include a ballast **470** that can be released or activated to alter the buoyancy of the device **450**. Any other method also may be

utilized to make the device with variable buoyancy. Additionally, the device **450** may also include a propulsion mechanism **480** that can be selectively activated to aid the device **450** to flow within the fluid path. The propulsion mechanism may be self-activated or activated by an event such as the location of the device **450** in the
5 fluid or its speed.

While the foregoing disclosure is directed to the preferred embodiments of the invention, various modifications will be apparent to those skilled in the art. It is intended that all variations within the scope and spirit of the appended claims be
10 embraced by the foregoing disclosure.